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PLANT DISTRIBUTION IN CALIFORNIA

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CALIFORNIA is easily first among the states of the Union in the variety and interest of its flora. Indeed there are few regions in the world which surpass it in these respects, and the problems dealing with the origin and distribution of this rich flora are full of interest.

In a paper such as the present one, it is clear that only the more obvious factors controlling plant distribution can be considered. There are many important but often very obscure problems which must be passed over here. Indeed the writer feels himself quite incompetent to deal at all with many of these.

Probably the most important factor determining the character of its flora is the geographical position of California. Covering almost ten degrees of latitude, $32^{\circ} 40'$ to 42° , it lies well within the warm temperate zone with conditions of temperature conducive to a luxuriant vegetation. The state is peculiarly isolated, as the high mountains and deserts to the east offer an impassable barrier to plants from the Atlantic side of the continent, while to the south are the deserts of Mexico and lower California, and on the west lie the shores of the Pacific. The state thus has many of the characteristics of an oceanic island. This isolation, no doubt, accounts for the extraordinary proportion of endemic plants found in California.

Aside from latitude the great factors controlling the climate of California are four in number, viz., (1) the great oceanic and continental barometric areas; (2) the prevailing west-to-east drift of the atmosphere characteristic of temperate latitudes; (3) the proximity of the Pacific ocean; and (4) the extraordinarily varied topography of the state.¹

The Pacific ocean, whose immense volume of water varies but little in temperature during the year, acts as a huge thermostat and gives the whole Pacific coast an extraordinarily equable climate. Along the middle California coast the water is cold, having an average tem-

¹ For details, see the very interesting account of the climate of California, "The Climatology of California," Alexander G. McAdie, Washington, Government Printing Office, 1903.

perature of 55°, so that the summer climate of the immediate coast is relatively very low. The coast region of California feels the full benefit of the proximity of the ocean during the summer, as the prevailing winds are from the ocean, and only occasionally do land winds occur. The hottest month in San Francisco has a mean temperature of only about 60 degrees, although it lies in about the same latitude as Washington, where the mean of the hottest month is nearly 20 degrees higher. On the other hand, the coldest month of the year in San Francisco is only 10 degrees less than the hottest, while in Washington the difference is more than four times as great. In very exposed places the difference may be even less marked, and practically the same temperature prevails throughout the year. The equalizing effects of the ocean are also shown in the slight differences in temperature due to the latitude. Thus between Eureka, on the northwest coast, and San Diego, at the extreme southern end of the state, equivalent to the difference between New York and Savannah, the mean annual temperature difference is only about ten degrees.

Temperature variations in California are far more a question of topography than of latitude. During the summer it is not unusual to find a difference of 30 to 40 degrees in the maximum temperatures on the same day between a coast station and a station 100 miles inland. Thus when at San Francisco the maximum temperature may be under 60 degrees it might reach 100 degrees in Sacramento or Fresno; while at San Diego, 500 miles south, it would probably be not more than 10 degrees warmer than in San Francisco. Much greater differences might be noted for some of the stations in the southeastern desert, where temperatures of 130 degrees have been recorded, with a monthly average temperature of 100 degrees. The lowest temperature in the state is in the High Sierra, where temperatures of about minus 30 degrees have been recorded.

Even a few miles are sufficient to make a great difference. Thus at Stanford University, about 30 miles south of San Francisco, the mid-day temperatures during the summer are usually from 10 degrees to 20 degrees higher than in San Francisco. This is due solely to the fact that the former is protected from the sea by a range of mountains shutting off the fog and much of the ocean wind to which San Francisco is fully exposed.

To a visitor from the eastern states the climatic conditions so totally different from those to which he is accustomed, are rather perplexing. Throughout the Pacific coast the year is divided practically into two seasons, the wet or winter season and the dry summer. To quote Bret Harte:

Warm and wet, and drear and dry,
Half a year of clouds and flowers,
Half a year of dust and sky.

These differences are much more pronounced in California than in the regions further north, and the annual precipitation falls off very rapidly as we proceed southward. Eureka, on the northwest coast of California, has more than four times as much rainfall as San Diego, on the extreme southern coast (the annual means: Eureka 46.04 inches, San Diego 9.52 inches).

In a sense the seasons are reversed when compared with those of the Atlantic states, as the summer, except in the northern areas and in the mountains, is almost completely a dormant period for vegetation. Of course, in the regions of heavy snowfall and severe cold, vegetation comes to a standstill in the winter, but in the lower elevations there is never a complete cessation of plant growth. Even in regions where there is an abundant summer vegetation, as in the Sierras, this mainly depends for its maintenance upon water in the soil derived from melting snow, as summer rains are of rare occurrence anywhere in the state. This long dry period, lasting sometimes in Central California for upwards of six months, no doubt accounts for the predominance of xerophytic plants in California. A large proportion of the trees and shrubs are evergreen, and conifers are the dominant forest trees. Among the herbaceous plants there is an extensive development of annuals, which germinate with the first rains and complete their growth before the dry months. Another type of herbaceous plants is seen in the very numerous bulbous and tuberous species, especially members of the lily family. The awakening of vegetation begins not in the spring, but in the fall with the advent of the first winter rains. With the cessation of rain in April or May vegetation goes to rest for the summer.

The conditions governing the rainfall in California are similar to those controlling the temperature, and are largely topographical. As in the temperatures there is an extraordinary difference in the rainfall at different points in the state. Some northern stations may have more than 100 inches in a year, while in the desert in the southeast, a year may pass with practically no rain at all. The highest mean annual precipitation given by McAdie is 81 inches at Upper Mattole, in Humboldt County, on the northwest coast, but in some years the rainfall exceeds 100 inches, and he notes one annual rainfall of 120 inches, at Laporte in 1896. At one station in the southern desert, Mammoth Tank, the mean annual rainfall is only 1.81 inches, while in some years practically no rain at all has fallen.

While in general, as we have seen, the rainfall diminishes southward, there may be a great variation between stations only a short distance apart, due to the topography. Thus at Boulder Creek in the Santa Cruz Mountains, about 25 miles distant from Palo Alto, there is over three times as much rain as falls at the latter place.

These differences in humidity are plainly reflected in the vegetation



FIG. 1. DENSE FOREST IN THE UPPER CANYON OF THE SACRAMENTO, NEAR MT. SHASTA.

in different parts of the state. In the cool humid coast region of the north are found the tallest trees in the world, the redwoods, while the density of these redwood forests is hardly equalled anywhere in the world. On the other hand, certain regions of the intensely hot and arid deserts of the southeast corner of the state can support no vegetation at all, and others not quite so arid have only the scantiest flora, composed of such extreme xerophytes as the cacti, creosote bush and palo verde.

The peculiar topography of California is therefore largely responsible for the distribution of its flora. In the middle region are the three parallel ranges of mountains, the outer and inner coast ranges and the

great range of the Sierra Nevada. At the north these ranges come together in a transverse range, the Siskiyous, between California and Oregon; and towards the south is a similar transverse range, the Tehachapi. Between these mountain ranges are numerous valleys, of which by far the most important is the great Central Valley, drained by the Sacramento and San Joaquin Rivers, and extending for half the entire length of the state.

The outer coast range receives the full benefit of the moisture-laden winds from the ocean, while the valleys lying inside of the range are very much drier, and this is still more marked in the great Central Valley and in the regions south of the Tehachapi, most of which are really deserts.

The outer ranges are only of moderate elevation, but in the Sierras are the highest peaks in the United States proper, while in Death Valley and the Colorado Desert are areas lying 300 feet below sea level. This gives a range of elevation in California of nearly 15,000 feet.

Combined with these extraordinary differences in elevation is an equally marked variation of soil conditions, suitable practically for every sort of plant.

Corresponding to the extraordinarily diversified conditions prevailing in California, it is not to be wondered at that the flora of the state presents a variety quite astounding to the botanist accustomed to the comparatively uniform vegetation of the Atlantic half of the country. Whereas in the regions east of the Rockies there are no important barriers to the free migrations of plants, aside from questions of temperature and moisture, in California there are many barriers against such migration, and one finds within the limits of the state distinct floras



FIG. 2. DESERT NEAR TUCSON, ARIZONA. (Photo. Dr. W. S. Cooper.)



FIG. 3. REDWOOD FOREST NEAR STANFORD UNIVERSITY. (Photo. Robinson & Crandall, Palo Alto.)

which differ much more widely from each other than any that could be found in the Atlantic half of the country. In the well-watered areas of Atlantic America, lying east of the great plains, there are many species that range practically over the whole area. Such trees as the white elm, oaks of several species, maples and hickories extend over pretty much of this whole area, and the same is true of many other plants, so that the flora is very similar throughout the range, the main differences being the addition of new species to the northern flora in the moister and warmer regions of the southern states, and the disappearance of certain boreal types.

In California, however, the difference between certain floras is absolute. Thus the contrast between the dense redwood forests of the north, where the vegetation is fairly tropical in its luxuriance, and the flora of the Colorado and Mojave Deserts, parts of which are absolutely destitute of vegetation, is about as complete as it could well be; and except for a few species of aquatics, such as the cat-tails of the marshes and ditches, it is doubtful if the two regions have a single species in common. Even within quite short distances one finds a remarkable difference in the type of vegetation, due to rapid changes in elevation, as in ascending the slopes of the Sierra Nevada, or to differences in soil and moisture, as in the transition from the redwood forests of the outer coast ranges to the flora of the open valleys lying east of the mountains.

In the mountains to the west of Stanford University, a distance of less than 10 miles, there is a very heavy growth of redwood, with the accompanying mesophytic flora, largely made up of northern types, *e. g.*, brambles, ferns of several species, lilies, violets, wood-sorrel, clintonia, lady slippers, trillium and other types quite familiar to the eastern botanist. These northern plants sometimes follow the beds of streams flowing into the valley, but the floor of the valley is for its most part only sparsely wooded, mainly with oaks—quite different from the eastern species, especially the characteristic live oak (*Quercus agrifolia*), which is so prominent a feature in the valley landscape of the coast region of California.

In places the open ground is covered with a growth of chaparral (dense scrub) made up of a variety of species. Among these are the poison-oak (*Rhus diversiloba*), the California buckeye, a woody composite (*Baccharis*), the toyon (*Heteromeles*), and other unfamiliar-looking shrubs. The open ground not occupied by the chaparral supports a growth of annual grasses, among which in the spring are masses of wild flowers, mostly annuals, but comprising a number of perennial species, especially bulbous Liliaceæ. These are mostly genera poorly represented in the eastern states (*e. g.*, *Lupinus*, *Trifolium*) or else entirely different genera, *e. g.*, *Gilia*, *Godetia*, *Orthocarpus*, and many others. These latter are most of Mexican affinities, but a good many

genera are peculiar to California. Later in the season and persisting until the autumn, are a small number of flowering annuals, mostly Compositæ. Among these perhaps the most characteristic are the tar-weeds of the genus *Hemizonia*.

As an example of change due to elevation, with, of course, accompanying increase in precipitation, the ascent of the Sierra Nevada from the great central valley is very instructive. This great valley has a scanty rainfall which is often insufficient for any tree growth away from the streams, and the level floor of the valley reminds one of the prairies of the middle west. The foothills develop a scattered growth of oaks, and a little higher up one finds the peculiar digger pine (*Pinus Sabiniana*). Somewhat higher up the yellow pine (*P. ponderosa*) appears, and at elevations of about 4,000 feet, that of the Yosemite, the open forest of the Sierras is well developed; but one must ascend still higher, about 6,000 feet, to see the fullest development of this wonderful forest as one finds it in the belt where the giant Sequoias grow. Here among the huge conifers is a rich growth of deciduous trees, oaks, maples, dogwoods and others, and many beautiful flowering shrubs and herbs. Along the streams and in the low ground are sub-Alpine meadows, in which grow a great variety of beautiful flowers—lilies, asters, orchids, painted-cups, the great hellebore (*Veratrum*), columbine, lupins, gentians, lark-spurs, monk's hoods, and many other showy species.

The forest is well developed up to about 8,000 to 9,000 feet, above

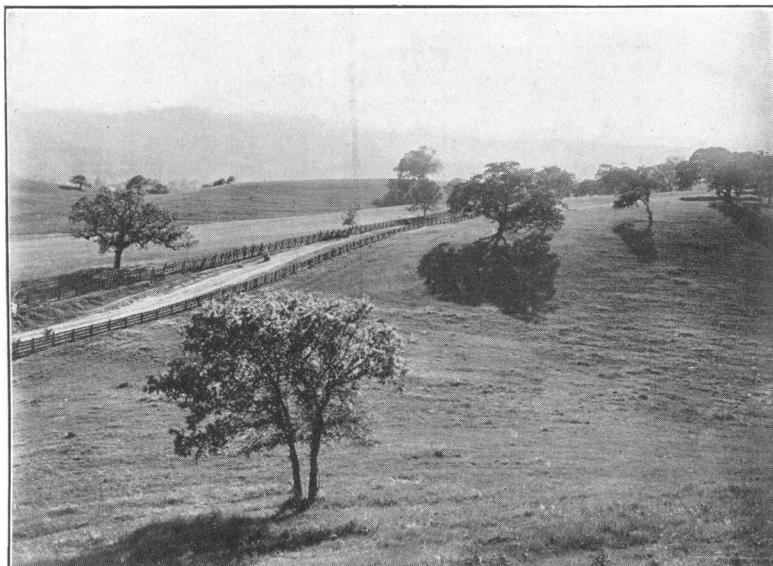


FIG. 4. FOOTHILLS OF SANTA CLARA VALLEY NEAR STANFORD UNIVERSITY. (Photo. Robinson & Crandall, Palo Alto.)

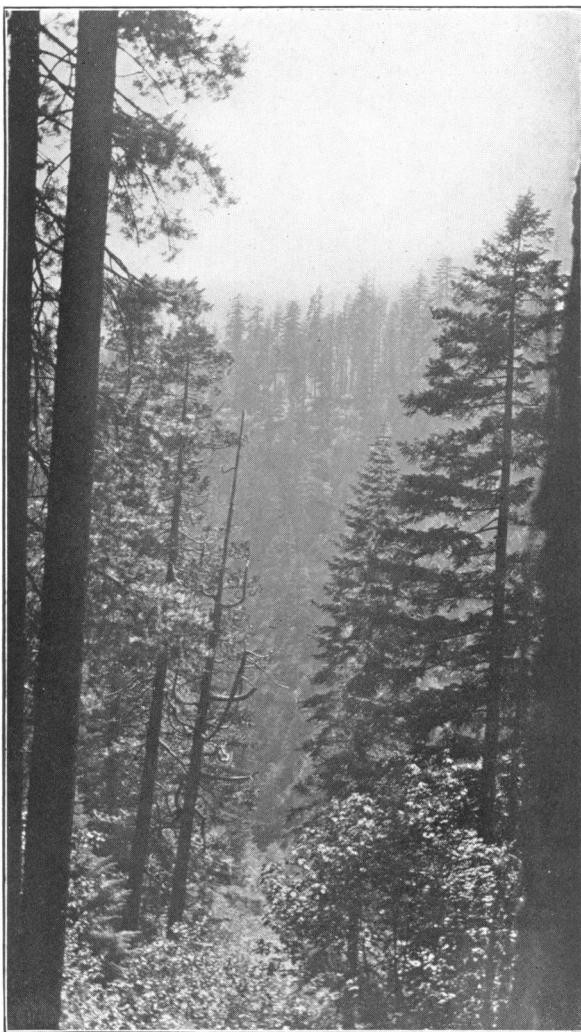


FIG. 5. CONIFEROUS FOREST NEAR MT. SHASTA. Douglas fir predominant.

which only such Alpine trees as *Pinus albicaulis* and *P. flexilis*, and the western juniper occur, hugging the ground and braving the tempests of the exposed summits.

Many species in California are extremely limited in their range, such as the fan palms (*Washingtonia*) found in a few cañons opening into the Colorado Desert; the great bush poppy (*Romneya*) of Southern California; and perhaps best known of all the several local coniferous trees, of which the Monterey cypress and Monterey pine, confined to a few miles of coast near Monterey, are the best known.

ORIGINS OF THE CALIFORNIA FLORAS

The southern part of California is geographically part of the Mexican plateau, and the plants are largely the same as those of the adjacent regions of Mexico, Lower California and Arizona. This is a more or less pronounced desert area, and the characteristic plants are most of them well adapted to resist long periods of drought. Shrubs with small tough leaves or almost leafless, like the "palo verde" (*Parkinsonia*), are characteristic of this region, and in many parts of it the cacti reach a great development. Mesquit (*Prosopis*) and yuccas of various species are also features of this region, as well as a good many annuals, which are particularly abundant in years of good rainfall.

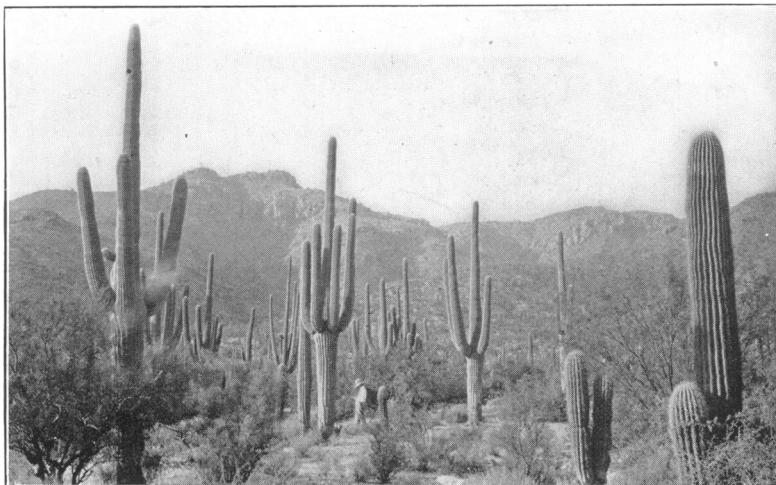


FIG. 6. DESERT NEAR TUCSON, WITH GIANT CACTUS, *Cereus giganteus*. (Photo. Dr. W. S. Cooper.)

In the mountains, with the increasing moisture in the higher elevations, a forest develops but much less luxuriant than that of the northern part of the state. One of the most striking types found in the southeast part of California is the palm, *Washingtonia*, already referred to. This is the only palm growing native within the limits of the state.

Many of these Mexican types, of both woody and herbaceous plants, extend northward through the drier valleys and along the mountain slopes to the extreme north part of the state.

Going northward, however, especially in the cool, moist regions of the coast ranges and the high Sierras, plants of a very different character begin to be abundant, and it is evident that these are plants of northern origin, and one encounters many genera familiar to the eastern botanist. Roses and brambles; huckleberries, rhododendron and azaleas; maples

and dogwoods; lilies, violets, trilliums, buttercups and other northern genera are common. Owing to the coolness and moisture of these outer coast ranges, many of these northern types, following the mountains south, reach well beyond middle California.

In this region there is a mingling of the northern and southern floras, which is particularly well illustrated in the regions about San Francisco Bay, where the northern types as a rule occur in the redwood belt, and in the shady cañons where there is an abundance of moisture, and lower temperatures than prevail in the open valleys and on the exposed slopes of the mountains. In the latter areas there is a predominance of southern species.

A characteristic form of this southern xerophytic vegetation is seen in the "chaparral," the dense scrub which covers the exposed hillsides and, also, to some extent, the floor of the valleys. This is well developed in the neighborhood of Stanford University, where the chaparral includes dwarf oaks, wild lilac (*Ceanothus*), manzanita (*Arctostaphylos*), species of wild currant, roses, a large shrubby composite (*Baccharis*), "yerba santa" (*Eryodictyon*), buckeye, poison oak (*Rhus diversiloba*), *Garrya*, *Adenostoma*, and others. This "chaparral" very much resembles the similar formation "macchie," "maquis" of the shores of the Mediterranean.

The redwood formation, which is largely controlled by the amount of precipitation—including the copious summer fogs—comprises a number of characteristic species mostly of northern affinities. Thus with alders, maples, willows and dogwoods along the streams, there are evergreen oaks of a very different type from the eastern species, and other evergreen trees and shrubs, the most notable of which are the madroño (*Arbutus menziesii*) and the California bay tree (*Umbellularia*), forms which are quite unrepresented in eastern America. The most characteristic trees of the open valley are scattered oaks, of which two species predominate, the live oak (*Quercus agrifolia*) and the valley white oak (*Q. lobata*). These usually grow scattered about the valley and foothills, but sometimes on northern exposures they form associations that are sufficiently dense to be called forests. The open ground is largely occupied by a growth of annual grasses, among which grow a great variety of beautiful flowers like *Nemophila*, *Platystemon*, the California poppy, lupins and other annuals, but also including a number of perennial forms, especially the bulbous Liliaceæ such as *Brodiaea* and the beautiful mariposa lily (*Calochortus*). Growing with these native plants, especially where the ground has been cultivated, there are certain introduced weeds which occur in great numbers and contest the ground with the native plants. Among these introduced weeds may be mentioned the wild mustard, the "filaree" (*Erodium*) and the wild oats.

Along the shores of the bay are extensive salt marshes with a characteristic and interesting flora.

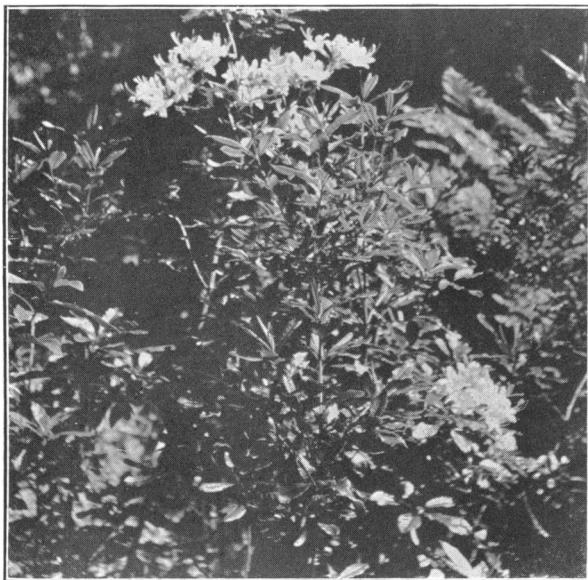


FIG. 7. *Azalea occidentalis*. A characteristic shrub of the moister forests.

A notable element in the Californian flora is one apparently of old world origin. In the northern coast region occur species like the Sitka spruce and western skunk cabbage (*Lysichiton*), which are also found in Kamtchatka; another old world genus is *Fritillaria*, of which species occur all the way from Alaska to San Diego, and one extends eastward as far as the Yellowstone Park. Of broad-leaved trees, the tan-bark oak



FIG. 8. CHAPARRAL FORMATION, LAKE TAHOE. The predominant shrubs, manzanita and species of *Ceanothus*.

(*Pasania densiflora*) is the only American representative of a genus largely developed in tropical and subtropical Asia, and the madroño (*Arbutus*) is also an old world genus which is not found in Atlantic America. Of herbaceous plants an interesting example is seen in the genus *Trientalis*, of which there is in eastern America a well-marked species, but the Pacific coast form is a variety of the old world *T. Europaea*. Whether these Eurasian types are comparatively recent immigrants, or whether they are relics of the old tertiary floras which have persisted on the Pacific coast, is not quite clear.

There are also examples among the lower plants, which apparently have had a similar origin. Among these may be cited the giant horsetail (*Equisetum maximum*), the fine fern *Woodwardia radicans* and a liverwort, *Targonia hypophylla*.

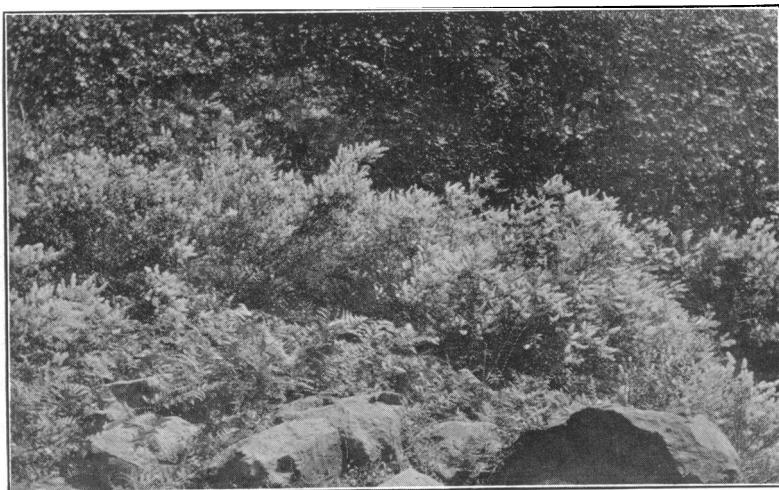


FIG. 9. *Ceanothus* sp. A characteristic chaparral shrub.

The seashore of California has a varied and extremely interesting flora. There are extensive sand dunes and beaches, as well as bluffs and rocky headlands. Among the striking plants of the dunes may be mentioned the tree lupins, species of *Mesembryanthemum*, the sand Verbena (*Abronia*), many showy Compositæ and others. Probably to the botanist the most striking features of this coast region are isolated groves or "islands" of conifers, of which there are several species of extremely limited range. The Monterey pine (*Pinus radiata*) and the Monterey cypress (*Cupressus macrocarpa*) are the best known.

Inside the shore zone lies, in middle and northern California, the outer coast range which sometimes comes close to the sea. Where the exposures to the strong ocean winds are not too great there is developed

in these coast mountains one of the most remarkable forests in America, and probably in the size and density of the tree growth one that is unequaled in the world. The predominant tree of this region is the coast redwood (*Sequoia sempervirens*), even surpassing in height its great cousin of the Sierra forests. In its northern ranges there are pure stands of these giant trees of extraordinary density, but southward the forests are usually more open and there is an intermixture of species, including the Douglas fir, *Torreya*, tan-bark oak, madroño and some other species. The limits of the redwood belt are practically determined by the sea fogs which prevail along the coast during the summer season. This fog takes the place of summer rains, and the vegetation of the redwood belt is largely mesophytic in character, with a predominance of northern genera. On the inner slopes of the ranges the moisture is usually insufficient to support a heavy growth of redwoods, and where they disappear they are replaced by shrubs and trees of a more xerophytic type, and these also largely disappear on the dry floor of the valleys.

In Central California there is a second range, the inner coast range, parallel to the outer one, and between these are numerous sheltered valleys, often of great fertility; while between the inner coast range and the Sierras lies the great central valley drained by the Sacramento and San Joaquin Rivers, which break through the inner coast range and discharge their waters together into San Francisco Bay.

These valleys have only a moderate rainfall, especially the great central valley, and those further south, and there is only occasionally developed in these associations of trees that can properly be called a forest. The floor of the valley and the lower foothills are usually covered with a growth of annual grasses, and where the uncultivated areas have been left we find in spring a profusion of the showy annuals and bulbous plants already referred to.

To the botanical student, probably the most interesting elements of the Californian flora are the conifers, which in size and variety surpass those of any other region in the world. These conifers reach their greatest development on the west slopes of the Sierras of Middle California at an elevation of some 4,000 to 6,000 feet. In this belt grow the giant Sequoias, accompanied by several other species, of which the most prominent are the yellow pine (*P. ponderosa*), the sugar pine (*P. lambertiana*), the white fir (*Abies concolor*), the incense cedar (*Libocedrus decurrens*), and the Douglas fir (*Pseudotsuga taxifolia*), all trees of gigantic size. At higher elevations other species supplant these to some extent, and altogether there are about 60 species of coniferous trees in the state, a larger number than occurs over all the rest of the United States.

True Alpine floras occur in the higher elevations, above 9,000 feet, but are less developed than in the moister regions further northward, as

in the Cascade ranges of Washington and the Canadian Rockies; but there are, nevertheless, many very beautiful true Alpine forms, such as the species of *Bryanthus*, gentians, phlox, primroses and various others.

The sub-Alpine flora is well developed wherever there is sufficient moisture, and the wet meadows full of brilliant flowers are very beautiful.



FIG. 10. CONIFEROUS FOREST, LAKE TAHOE. The tall tree is white fir (*Abies concolor*), the predominant species in this region. Note the man standing near the base of the tree.

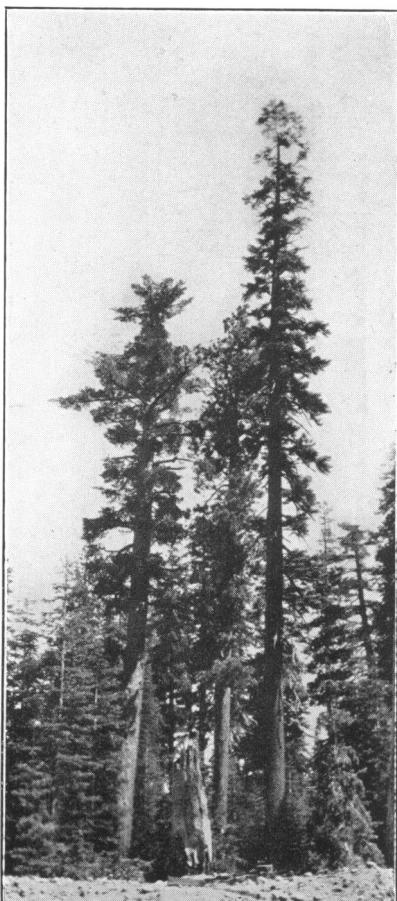


FIG. 11. SUGAR PINE (LEFT), RED FIR (*Abies magnifica*) (RIGHT). Near Lake Tahoe, about 6,500 ft. elevation.

While most of California north of the Tehachapi range has an adequate rainfall, the southern part of the state, except near the coast, is largely a desert, and in some parts deserts of the most pronounced character, as in Death Valley and parts of the Colorado Desert.

The flora of this region, as we have already indicated, is mainly Mexican and has very little in common with much of the northern part of the state.

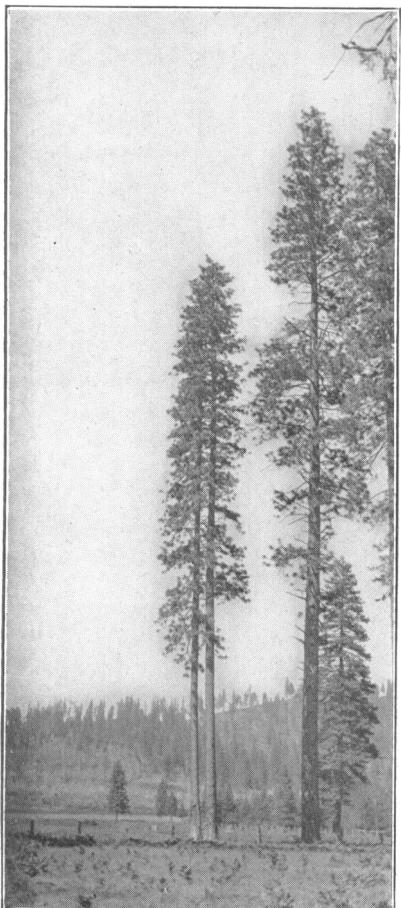


FIG. 12. YELLOW PINE (*Pinus ponderosa*). Near Mt. Shasta, elevation about 3,000 ft.

A marked feature of most of Californian plants is their "xerophytic" character, *i. e.*, their adaptation to long periods of drought. This is conspicuous in the trees, which are largely conifers or else broad-leaved evergreens, like the live oak, madroño and laurel. It is also marked in very many of the shrubs, which have small evergreen leaves. The shrubby plants making up the "chaparral" are largely

evergreen, *e. g.*, wild lilac, the manzanita, chinquapins, dwarf oaks and others.

Owing to the isolated position and numerous barriers within the state, California presents an extraordinarily large number of "endemic" or peculiar species, some of which are of very limited range, such as the peculiar conifers of the coast region. I have not been able to find any tabulation of the proportion of the endemic species, but it



FIG. 13. INCENSE CEDAR (*Libocedrus deplanchei*), LAKE TAHOE.

certainly must be very much greater than that of any other part of the United States. The marked development of endemism is seen in very many large genera, such as *Calochortus*, *Lupinus*, *Trifolium*, *Gilia* and various others. The majority of these species is exclusively Californian. Thus in the genus *Lupinus* about half of the known species are found in California, and a large majority of these is peculiar to the state.

Many species are extremely variable and the limits of species difficult to determine. California should be an exceptionally favorable region for studying variations under natural conditions. Perhaps some light might thus be thrown upon the vexed question of "mutations," and other factors concerned in the origin of species.